TELEPHONE SYSTEM DESIGN

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Contents

1. GENERAL

1.1 This section provides REA borrowers, consulting engineers, contractors, and other interested parties with information for use in the design of rural telephone systems. It presents, in particular, system design considerations pertinent to the preparation of the Area Coverage Design (ACD), TE & CM Section 205, or Supplemental Loan Proposal. (See REA Bulletin 320-14, "Loans for Telephone System Improvements and Extensions.")

1.2 This section replaces material formerly found in paragraphs 6 and 7 of REA TE & CM-205, Issue No. 4, March 1963. It covers for the first time or with increased emphasis (1) All one-party service, (2) Fine Gauge Design, (3) 1971 Transmission Criteria, (4) Station Carrier, (5) Common Mode Operation, (6) PCM Carrier, (7) Automatic Number Identification (ANI), (8) Subscriber Owned Equipment, (9) Van Type Metal Buildings, (10) Common Control Switchboards, (11) Underground Cable and Conduit, (12) New Services and (13) Coaxial Cable.Designers must be familiar with these topics if they are to design the most economical system for an area.

1.3 The design criteria are intended to reflect rural communications requirements for the 1970's. Some primary concerns are:

a. Expansion of telephone service to all rural homes.

b. Emphasis on the provision of one-party service for all subscribers.

c. Aesthetics, ecology, employees and the public.

d. Ability to provide services upon request.

e. Innovation of new subscriber services made economically and technically possible by advancements in electronics.

1.4 Figure 1 shows the base for 797 REA borrowers, upon which new services and facilities will be superimposed in the 70's. It shows for example that 61% of the central offices have 200 Working Lines or Less. How an individual system differs from Figure 1 depends upon how up-to-date the system is.

1.5 The design will indicate the telephone plant required for the system and the total estimated cost of construction of the facilities. The design is the major engineering instrument influencing the proposed system and the adequacy of the services it will be able to offer. The subscriber data and the design enter into the determination of the economic feasibility of the loan.

1.6 The manager of the system should be kept continually informed by the engineer of the status and proposed characteristics of the design so that important factors can be jointly considered. Major features of the design (such as the addition or deletion of central offices, extensive use of station carrier, etc.) must be coordinated with the manager.

2. BASIS OF THE DESIGN

2.1 The design must be based on an up-to-date area coverage survey (see TE & CM-206, "Area Coverage Survey") which forecasts subscriber requirements and trends for the design period. There should be available adequate maps of unserved areas and up-to-date as-built maps for the existing areas where reinforcing is planned.

2.2 The design should also be based on an adequate field survey by the engineer to obtain information concerning routing of the outside plant, general condition of the existing system, best choice of facilities, new routes that may be required, etc. The survey should include factors likely to have a significant effect upon the cost of construction.

2.3 The connecting company arrangements must be determined for toll trunking, operator assistance, EAS trunking, automatic number identification, borrower-provided toll boards, automatic toll ticketing, etc.

2.4 The engineer should consider alternate plans of service (see Paragraph 3.3) and make cost comparisons of the alternates from an annual cost as well as a first cost basis.

3. FUNDAMENTAL SYSTEM DESIGN CONSIDERATIONS

3.1 Primary Design Objectives

3.11 The main objectives of the design of the system are to provide facilities to serve adequately the subscriber needs at a reasonable cost and to provide a sound basis for a loan. The fulfillment of this objective will be affected by the level of accuracy in forecasting demands for service and subscriber growth for the design period. Another factor is the extent of knowledge of technological advances in the com-

munications industry which may change and improve the methods of providing more economical and better service. The design should be as forward looking as possible and should incorporate recent developments to the extent that sufficient technical data is available to assure that new features are technically sound and economical. Developments that have not yet progressed to "REA Field Trial Status" should not appear in the design although they may become acceptable prior to the time plans and specifications are prepared.

3.12 Recognizing the above limitations, the program outlined in the design is based on forecasts of the anticipated service needs. The studies are intended to arrive at the optimum design for the projected needs for service during and to the end of the design period, usually five years. In fast growing areas it may be a shorter period. With long range planning in mind, the requirements of the system to meet the estimated demands for the design period are prepared in such a manner that they will also provide for economical system expansion beyond the design period.

3.13 While long range planning will help to determine the best system design, the REA loan will generally be based on the cost estimate for the 5-year facilities. The economic feasibility of the loan will be determined by the revenue anticipated from subscribers for the system as designed. The investment in 5-year plant should therefore be given careful study and should be the minimum consistent with the desire to provide facilities capable of economical future expansion to meet the long range objectives.

3.14 To arrive at an optimum design, cost comparisons of several different methods may be required. Methods of making such studies are discussed in later paragraphs.

3.15 All design should be in accordance with design and construction standards established by REA for borrowers' systems. These standards are set forth in the various sections of the REA Telephone Engineering and Construction Manual (see REA TE & CM-102, "Numerical Index"). The system engineer should be thoroughly familiar with this manual before initiating a design and should refer the individual doing the detail design to the appropriate sections during the design process.

3.2 Use of the Area Coverage Survey Data

3.21 The ACS provides an estimate of the potential subscribers that will take service in the design period. It is not possible for the ACS to predict the grade of service (1) when more than one grade is to be offered or (2) the location of specific potentials which will want service or (3) exactly when a particular establishment will desire service, if at all.

3.22 In areas not previously served by REA borrowers, as a result of a detailed field survey, all establishments will be shown on the ACS maps and will be rated as to their status or prospects as subscribers.

3.23 There may be sections of the country where the population is decreasing and will therefore have a significant number of establishments which have uncertain possibilities as future subscribers. If the design and construction of the telephone system is to be correctly engineered for adequate service at minimum cost, all possible means must be taken by the engineer and the owner to insure that the data and the growth picture as presented in the ACS are reflected in the subsequent design.

3.24 In contrast there are areas where growth might develop from future establishments whose actual location is hard to predict two or more years in advance. Therefore, the engineer should at all stages of the design incorporate as many flexible features as possible without incurring cost penalties. Carrier systems are available that will assist in doing this. This makes it possible to provide service temporarily with carrier which can later be replaced with cable facilities or possibly even a central office.

3.25 REA TE & CM-210 provides detailed information concerning recommended design procedures for establishing the size of outside plant facilities after the subscriber distribution is determined.

3.3 Analysis of Alternate Design Considerations

3.31 For important segments of system design, the engineer has the responsibility of making cost comparisons to select the plant facilities on the basis of the lowest annual cost to provide the services required. These studies may involve:

a. Analysis of central offices--number, location, size, and type of equipment.

b. Methods of expanding plant facilities for upgrading subscriber service.

c. Alternate means of providing trunk facilities--physical, electronic (voice frequency repeaters, carrier, radio, etc.).

d. Alternate means of providing subscriber circuits - physical (aerial, underground or buried cable, distribution wire, etc.); electronic (station carrier, loop extender, VF repeaters, open wire carrier, mobile radio, etc.).

e. Choice of retaining or replacing serviceable plant items.

f. Various methods of meeting transmission requirements, including common mode arrangement, individual line treatment, equalization, etc.

g. Automatic toll ticketing, automatic line or number identification.

h. Extended Area Service (EAS) - direct trunks or tandem operation.

i. Division of toll line ownership; carrier and voice repeater ownership.

j. Selection of microwave facilities.

k. Use of underground facilities such as cable vaults, manholes, and ducts.

3.32 The proper determination will be obvious for some of the above items for a particular system. For others, an economic study will be required using major design and construction criteria, plus possible time period analysis, such as the present worth of the annual charges.

3.33 Application of Cost Comparisons to Specific System Designs

3.331 From the ACS, the engineer determines the extent of the area to be served, the number and distribution of existing and potential subscribers, and the grade of service desired. From a field survey and plant records the engineer will know the condition and location of the existing plant facilities and conditions in unserved areas. There may be a number of plans which can serve as a basis for the system design. Two or three can usually be selected, by visual inspection, for detailed analysis. The engineer should study and compare only those costs which would be of significant difference in each plan. If an alternate plan differs in the results it offers, such as quality of service, quantity of circuits, transmission, etc. proper weight must be given to the difference when interpreting the results of the study.

3.332 Sufficient information for a decision usually can be obtained from comparing large size cable plant, station carrier, central office equipment, trunking requirements, and buildings. When a point is reached where one plan is clearly higher in cost than the other the study can be ended.

3.333 Where two plans are nearly equal in cost, the following factors should be considered.

a. The plan that requires the minimum initial investment in plant facilities to serve the subscriber estimate. For example, Plan A-(substantially all physical plant facilities) might have an annual cost about the same as Plan B with extensive amounts of carrier. If there is an extensive growth expected evenly over the full five years select Plan B, because minimum physical plant can be expanded for growth with carrier equipment and annual charges deferred until the necessary channels are actually added later as the subscriber growth dictates. Cable reinforcement will be required beyond five years. On the other hand, if most of the growth in circuits occurs at cutover to one-party Plan A (the all physical plan) at the same cost will permit substantial future growth with lower cost carrier likely to be available in five years.

b. The capability of the respective,plans to reuse existing plant in satisfactory condition where doing so would result in requiring significantly less new investment. The plan which reuses the greatest amount of existing plant and if it quires the least amount of new capital should be favored, other things being equal.

c. The capability of the respective plans to provide for unforeseen circumstances such as unanticipated growth or unplanned service demands.

d. Capability of the plans to provide for economical expansion because the demands for communication services are increasing at an accelerating rate.

34 The engineer should list factors influencing the design choice in addition to strict first cost and annual charge comparison. a plan has been selected, the design should be developed in detail he cost estimate prepared for the facilities required.

5 It is not intended that the engineer apply annual cost comparisons to such an extent as to interfere with practical design considera- . For example, strict annual charge comparisons for an outside plant might show that the circuits should change from aerial to buried, from on carrier to physical, or from retained plant to new plant or from distribution wire to buried wire or some such arrangement at various

points. This would create an impractical and from an operating standpoint uneconomical design even though it might be shown that the theoretical annual costs were lowest according to the analysis for each segment.

3.336 In certain elements of project design, sufficient historical data have been accumulated on which to predicate the choice of facilities without detailed analysis of the annual costs---for example, (1) wherever burying cables in rural areas is practical, no comparison with aerial cables is necessary; (2) 24-gauge cable and central office mounted voice frequency repeaters are more economical than 22-gauge cable without voice frequency repeaters. REA standards set forth in the Telephone Engineering and Construction Manual and various REA standard specifications are also frequently based on historical data. The engineer does not have to consider comparisons for segments of plant where standards exist, however, this should not be used as a justification for not making comparisons between established and new techniques.

3.337 REA TE & CM 218, "Plant Annual Cost Data for System Design Purposes," provides information to assist in cost comparison studies. Typical depreciation and maintenance rates for various types of plant are indicated. Where reliable data for the system being designed is available, it should be used instead.

4. DEVELOPMENT OF THE SYSTEM DESIGN

The paragraphs which follow outline some of the considerations which must be followed in comparing alternate designs and in preparing the detailed studies of the plan which is finally selected.

4.01 Location and Establishment of Central Offices.

4.011 The number of central offices which should be established to serve the area, is determined by making a study of the costs and advantages of several possible alternate arrangements.

4.012 It will be seen that the determination of the optimum number of central offices requires the engineer to achieve a balance between (1) the savings to be realized in major outside plant facilities and (2) the additional expenditures required for trunk plant, central office equipment and buildings, and (3) the difference, if any, in annual revenue and expenses between the plans.

4.013 As a general rule, a system which consists of only one central office requires minimum expenditures for trunks, central office equipment and buildings, but such an arrangement requires more expenditure for outside plant and/or station carrier equipment which may become a greater burden in the future. If the same service area is divided into more than one

entral office area, the trunking, central office equipment, and build-ng costs are multiplied. To be economical these increases must be off-et by savings in outside plant. In certain areas the availability of entral office codes may also be a consideration. The best overall bal-nce should be determined by studies of several alternate arrangements.

4.014 EAS trunk groups can be eliminated between small offices when existing central office areas are consolidated. Combined trunk roups can be operated more efficiently than small groups between several mall offices. In addition, central office codes can be kept to a mini-um; cost of new sites may be saved; existing building space may be uti-ized where available, etc. Telephone companies must consider carefully he advantages of planning for larger central offices at fewer locations erhaps replacing or avoiding small central offices with electronic switch-ng units.

4.015 In the 70's subscribers in rural areas will be expecting services such as pushbutton dialing, call waiting, three-way calling, call ransfer, speed calling, facsimile, data service, etc., now only avail-ble in the largest cities and practical in large central offices.

4.02 Central Office Equipment

4.021 It has generally proven practical and economical to utilize unat-tended dial central offices for switching local traffic. These ffices are in turn connected to attended offices which serve as direct istance dialing (DDD) operator assistance and information centers, etc.

4.022 With the rapid development of rural service during the last two decades, it was necessary to establish numerous small central ial offices to reach rural subscribers within transmission and signal-ng limits in existence at that time. With the advent of electronic ain devices permitting economical long loops, and new types of carriers, t is expected that future central offices will become larger and more ersatile. Resistance is important because of its effect on signaling d supervision of the circuit by the central office equipment. New al central office equipment conforming to REA specifications is re-ired to operate satisfactorily with subscriber lines up to 1900 ohms, cluding the telephone set. For loops exceeding this limit, long line apters or loop extenders are needed with the central office equipment. isting retained central office equipment loop limits should be investi-ted as they may be as low as 1000 ohms or range upward to 1900 ohms pability. Signaling limits can be extended economically.

.023 Inward Direct Distance Dialing is essential with dial offices, outward DDD is very desirable. If the telephone system has en manually ticketing considerable toll traffic and obtaining appreci-le revenue from this source, it is desirable to study means for continu-

ing this income. It is unlikely that either a large or small <u>all manual</u> toll switchboard can continue to be operated economically; therefore, the advisability of automatic toll ticketing equipment should be considered for existing large manual toll centers. Such equipment is now available to perform the complete accessing, timing, ticketing, and recording functions; newer types are now available that provide all of the necessary features for inter-toll access and are compatible with Bell System equipment. An end (Class 5) office can be equipped to furnish subscriber identification to an AMA center either Bell or Independent owned. Identification of the calling number can be passed on verbally to an operator (ONI) for recording when the end office provides multi-party service. However, the preferred method is to transmit the calling number automatically over the trunk to the AMA center when all one party or one and two party service is offered. Some types of ticketing equipment may also be adapted to handle "person-to-person," collect and special service (PPCS) calling. Access trunks to the toll office must be provided along with appropriate signaling apparatus. A quality of toll service is desirable that is comparable or better than excellent local service (not worse than P=.01 for toll trunks).

4.024 A study must be conducted on the economics of methods for handling toll calls and it is essential that a conference be held with the connecting company involved to obtain agreement for automatic toll ticketing of dialable calls and the forwarding of person-to-person, assistance, credit card, and similar calls to connecting company operators. TE & CM-157, "Customer Toll Dialing," contains additional information regarding the economics and the use of ticketing equipment. It also outlines examples of the economics of automatic number identification (ANI) equipment at small and medium size tributary offices. TE & CM-328 discusses types and features of ANI equipment. An alternate method that is somewhat less costly is to have the calling subscriber dial an extra preliminary digit (circle digit) as a part of the access code. Although this latter technique has been available for about ten years, its use is declining. REA borrowers generally prefer operator identification on party lines with ANI on individual lines.

4.025 For central office switching equipment, the engineer must develop the most suitable features to be included. REA TE & CM-325, "Application Guide for the Preparation of Detail Central Office Equipment Requirements" discusses many of the alternates to be considered. Common control equipment (electronic or crossbar) should be planned for new offices (1) over 1,000 lines or (2) where complex switching beyond the capability of direct control equipment is required. The capability of new central office equipment to handle anticipated new services such as pushbutton telephones, data sets, abbreviated dialing, call waiting, 911 emergency callings, etc., is becoming increasingly important.

.026 There will be instances where a borrower is faced with the problem of substantial growth in subscribers and services required which re beyond the capacity of existing step by step offices. Some alternates ich must be analyzed are:

a. Expanding with additional Step-by-Step equipment possibly supplementing with register-senders, or special appliques to facilitate handling required new services.

b. Replacement with common control central office equipment.

027 The choice should be based on all pertinent information that can be obtained. Data is required concerning the existing dial tchboard. Minimum data should include the manufacturer, model, year manufacture, quantity of equipment, and estimate of the condition. t is likely to be retained a switching diagram will also be required.

8 Once the type of central office equipment has been established, the engineer can develop the number of lines required from the r of subscribers, line fill and circuit data. The number of intere trunk terminations and switches can be determined as a result of runking study and negotiations with the connecting company. Based ese determinations, the cost estimate for the central office equipcan be prepared.

9 Information on central office equipment is included in the 300 Series of sections of this manual and in the REA TE & CM-156, nwide Toll Dialing," -157, "Customer Toll Dialing," and -810, al Office Electrical Protection".

Central Office Area Boundaries

As the engineer determines the number of central offices to serve the area, he must establish the central office area boundaries. as possible, the central office area should include all subscrio have a definite community of interest with each other. If a community is divided into two or more central office areas, exarea service should be provided between these areas.

At the outer extremities of two contiguous central office areas, will be subscribers who may have nearly equal interest in the s. The boundary between central office areas should be established g to the community of interests of the subscribers. However, the area should not be distorted to serve a selected group of subif severe economic penalties result.

033 Central office area boundaries should follow natural or cultural features of the area insofar as possible. Using rivers, ridges, ilroads, etc., as the dividing line between central office areas help avoiding frequent construction of river or railroad crossings or other es of costly construction and makes the dividing line easier to justi- to the subscribers.

04 Central Office Location

041 The location of the central office should be at or near the point from which outside plant facilities may be most economically pro- ied, and from which the administration and maintenance of the office n be conducted. Central office areas are seldom symmetrical in shape, d the subscribers are never evenly distributed throughout the area. cinities where subscribers are concentrated tend to pull the central fice location in their direction.

.042 Computer programs have been used in determining the best location for central offices in large cities, but trial and error compari- ons of various locations and engineering judgment are usually employed n determining the wire center in rural areas.

4.043 Practical considerations may require that the central office be shifted from the ideal location to a less desirable location. ome of these considerations are: the cost and availability of land at he preferred location, accessibility by all weather roads, fire hazards, n adequate and reliable power supply. Additional information regarding he location of the site is contained in REA TE & CM 301, "Central Office Buildings."

4.044 The foregoing discussion applies primarily to central office loca- tions in predominately rural areas. The same general principles, however, apply to locating an attended central office in more populous areas. In addition, the availability of a work force, taxes, water sup- ply, and sewage disposal should be considered if a business office or attended dial office is involved.

4.05 Study of Traffic Data

4.051 The engineer must develop the traffic data needed for planning the central office facilities and for planning toll and any ex- tended area service trunks. Circuit requirements are forecast based on usage shown by the data, plus judgment and knowledge of expended trends and predicted growth.

4.052 Some systems may have current traffic information available from toll separations or other traffic studies which can be used to develop the needed traffic data. Calling information associated with

large individual toll users should be adjusted or deleted if the traffic data is being prepared on a per subscriber basis.

4.053 Traffic tables and other data to be used in traffic calculations will be found in the 500 Series of sections of the REA TE & CM.

4.054 Generally, traffic studies are not required at the ACD or Supplemental Loan Proposal stage but should be made during the busy season just prior to the preparation of central office plans and specifications.

4.06 Connecting Company Services and Arrangements

4.061 In order that the telephone system may provide its subscribers with service beyond the immediate borders of that system, interconnecting and interchange of traffic with a connecting company (or companies) will be necessary. Coordination between the owner and the connecting company will be required to insure such service. REA Bulletin 340-3 discusses this matter in detail and, therefore, reference should be made to it. The engineer should be thoroughly familiar with provisions of the Bell System standard traffic and operator assistance (DSA) agreements in order to assist the owner in working out satisfactory connecting company arrangements. Information on the traffic agreement will be found in REA TE & CM 225, "Bell System Traffic Agreement."

4.062 Extended area service (EAS) is desirable between neighboring exchanges having a definite community of interest with each other through school, business, or other association. See REA Bulletin 411-1 "Extended Area Service." It is essential that equitable agreements for EAS arrangements and equipment cost sharing be negotiated with the connecting companies involved.

4.063 Connecting company agreements may have a significant effect on the design of the system. The terms of the traffic agreement may determine whether or not it is desirable to consider automatic toll ticketing for the offices, or otherwise arrange to time and ticket specific calls. The operator assistance and extended area service agreements may also affect design characteristics.

4.064 It is necessary to obtain a general idea of the possible connecting company arrangements before undertaking the detail work of developing the design. After determining tentative arrangements, proceed with a study of alternate plans. Upon completion of the studies to determine the number, type, and location of central offices and their respective service areas, the engineer and the owner should meet with the connecting company or companies if there are significant changes from existing arrangements and discuss the detailed requirements for improving transmission,

for handling toll, EAS, automatic toll ticketing, assistance and service calls, etc. (See REA Bulletin 340-3). The results of such a meeting will provide further guidance to the engineer in the development of the system design.

4.065 The borrowers' engineer should review any connecting company arrangements to select the most economical solution. Every effort should be made to avoid unnecessary equipment as may result when carrier systems are connected back-to-back or voice frequency extensions of carrier are suggested.

4.066 Since the charges and toll revenue resulting from the connecting company arrangements will play a part in determining the annual expenses and revenue of the system, these items should be discussed during the meetings with connecting companies along with the discussion of the actual facilities involved. When the facilities have been determined, it is essential that the terms and conditions under which these facilities and connections will be provided are covered in the minutes of the meeting or are in letters of intent to the owner from the connecting company. (The ACD will be considered incomplete until such minutes, letters or preferably a contract to determine the annual expenses and revenues to the owner for the connecting company arrangements have been received. The REA field representatives should receive notice of any delays in obtaining letters or contracts.)

4.07 Outside Plant

4.071 Outside plant constitutes a large part (generally about 50 percent) of the total investment in telephone plant which must be constructed to provide service in rural areas. In developing the outside plant facilities the engineer needs to determine (1) if the preferred buried plant can be used, (2) the most economical sizes and gauge of cable, (3) when and where to provide them, (4) where to use special facilities with extra protection, etc. Engineering decisions must be made concerning retaining useful existing outside plant in lieu of replacing it with new plant, placing additional circuits on existing pole lines, paralleling existing buried plant, paralleling power lines (See REA Bulletin 361-8 "Inductive Coordination of Power & Communication Facilities") or of adding plant on new right-of-way.

4.072 Buried Cable and Wire Facilities

4.0721 During the 60's, there have been major improvements in techniques for placing buried wire and cable which have resulted in less overall labor costs in burying plant than previously was possible. The reduction in the cost of plowing, along with the improved wire and cable designed for "direct burial", has made the construction of buried plant widespread. During 1970 more than 85% of REA's borrowers' outside plant

construction was buried. See Figure 2 "Investment in Telephone Plant" for the changing makeup.

4.0722 Buried plant is generally more economical on a first cost basis than aerial or plant in conduit. Exceptions where this economic advantage may not be realized are in urban areas or areas of extensive rock formations. In such cases, a combination of buried and aerial plant may prove to be the most economical construction for the system. Conduit may also be necessary although quite expensive.

4.0723 Although the correction of damage or faults may be more expensive in individual situations, buried facilities are much less exposed to physical damage than aerial facilities. Experience has shown that such corrections are needed less often. Fewer failures mean longer periods of satisfactory operation and consequently, greater reliability and improved subscriber satisfaction. Buried plant is particularly advisable in areas of frequent ice storms and high velocity winds. It is generally not exposed to power line contacts. In addition, buried plant will satisfy the growing impetus from the public and from local authorities for the improvement and preservation of the aesthetic values of the rural countryside.

4.0724 Advantages for consideration of buried plant are as follows:

a. Rapid construction is attained

b. Staking is less complicated

c. There are fewer right-of-way problems

d. There is reduced susceptibility of damage from vehicles

e. There is more safety for workmen (falls and electric shock).

f. It is not subject to wide temperature variations

g. Minimum exposure to corrosive elements that may be present in the atmosphere.

4.0725 In view of the advantages and the major improvements in materials and construction techniques such as greased filled cable and measures to protect from corrosive elements existing underground or for gopher protection, the engineer should reexamine situations where it was formerly considered impractical or uneconomical for burial of cable or wire.

4.0726 It is desirable but not necessary to consider an entire system (or even a whole exchange area) for burial. Sometimes it will be necessary to construct aerial plant in small towns because of paving or other utilities precluding economical plowing of telephone cable or wire, but conditions may be entirely favorable for burying the rural plant. Aerial inserts may be used where ledge rock is encountered or for meeting peculiar terrain conditions (such as bogs) not suitable for economical buried plant construction but inserts should be kept to a minimum.

4.0727 When using right-of-way for buried plant future reinforcement must be considered. The initial cable may be buried at increased depth with the reinforcement at a lesser but safe depth, or close to one edge of the right-of-way with the reinforcement near the opposite edge. Where future plowing may not be practical an oversize cable or a flexible plastic conduit may be installed initially.

4.0728 TE & CM-640, "Design of Buried Plant," TE & CM-641, "Construction of Buried Plant," TE & CM-642, "Staking of Buried Plant," TE & CM-816, "Electrical Protection of Buried Plant," discuss other considerations involved in determining the application of buried plant.

4.073 Miscellaneous Cable Items

4.0731 Split pipe may be used on bridges to attach and protect the wire or cable lead. For railroad crossings, aerial inserts have been supplanted by the technique of pushing pipe through the road bed and continuing the buried facility. TE & CM-617 "Railroad Crossing Specifications" discusses this further.

4.0732 Composite cable is the combination of two gauges of conductor under one sheath. During the past ten years such a combination has proven to be less economical than two separate cables and may require long delivery periods from the factory. We therefore recommend it not be used.

4.0733 The annual cost of providing two separate cables, one of which is heavy gauge, as the means of meeting transmission and signaling objectives should be compared with the annual cost of other methods of achieving the same objectives. Other possibilities to consider are loop extenders, long line adapters, various types of carrier equipment, and central office and field mounted voice frequency repeaters. Separate cables may sometimes be desirable for trunk circuits.

4.0734 Large size paper insulated conductor cables may be considered for aerial or underground (in conduit) installations. Conductors are color coded according to a standard grouping (not fully color

coded as PIC). The preferred outer covering is corrugated aluminum tape and an overlapped soldered seam steel tape with an outer polyethylene jacket. It is referred to as stalpeth cable. These cables are manufactured in standard sizes up to 3600 pair 26 gauge. Coarser gauge conductors are available with the maximum number of pairs being held to that standard size that will give a diameter less than 3.5 inches. They may be chosen for applications where their electrical characteristics (lightning and transmission) are found to be satisfactory. Situations to consider might involve large feeder cables. It is not desirable to introduce frequent splice openings in paper insulated cable. Pressurization is frequently provided. If existing conduit is filled with full size PIC cables paper cable provides a means to maximize the number of pairs that can be installed in the limited space.

4.074 Underground Cable

4.0741 Cable in conduit is very expensive but should be considered when conditions are appropriate:

a. Where a duct can be made available in an existing conduit system.

b. Where aerial cable is not permitted, surface restoration costs are very high and direct burial appears to be impractical.

c. For crossing highways or other situations where aerial crossings or direct burial are not allowed or are inadvisable.

d. Entrances to a central office where appearance is especially important and direct burial is not practical.

4.0742 Tile, Concrete, Asbestos cement, Fiber and Plastic Duct are available. Flexible plastic duct may be plowed in separately or at the time a buried cable is installed.

4.0743 In REA borrowers' systems, underground cable is generally 600 pairs or larger. In 50% of the cases manhole spacing is 400 feet or less and in 90% of the cases it is 700 feet or less.

4.0744 In REA borrowers' systems 40% of the duct feet are multiple Tile, 25% Asbestos Cement, 15% Plastic and 15% concrete. They have an average duct fill of 50%.

4.075 Joint Buried Plant Construction

4.0751 Joint burial of electric and telephone facilities is the placement of both these in a common trench either by plowing or trenching. It may be classed as fixed separation where the electric and telephone cables are everywhere separated by a specific minimum distance or random separation which eliminates the minimum separation if specified rules are followed.

4.0752 Until the 1960's, almost all buried construction by electric and telephone companies was separate from each other. The cost of trenching and precise separation of the cables previously made it advantageous to place the facilities some distance apart.

4.0753 The fixed (minimum) separation distance requirement for joint buried plant usually means trenching will be required and the cost will be increased. If this is a requirement in the area by the state or local code, it will probably be more economical to place the cables separately. When random separation is allowable, both electric and telephone cables may be plowed in together or laid in the same trench.

4.0754 If the telephone company and the electric utility consider joint buried construction, coordination of a number of factors, such as length of joint buried sections, depth of burial, identification of the cables, bonding, type of housings, division of costs, location of distribution and service runs, etc., will be essential. See TE & CM 640 and its addenda.

4.076 Aerial Cable

4.0761 Aerial cable facilities have been steadily improved and are comparable to buried cables in terms of serviceability and except for some extreme situations, reliability. Polyethylene jacketed color coded types are recommended, and described in REA specification PE-22. Ready access enclosures makes rearrangements of these cables less costly than paper insulated types.

4.0762 In urban areas, aerial cables are more economical than buried in many cases due to below the ground congestion from other utilities, cutting and restoring concrete or other hard surface material and the fact that drops are closer together and can be taken off conveniently and inexpensively but lowest first or annual cost should not be the only consideration.

4.0763 TE & CM-626 "Staking of Aerial Plant," TE & CM-627, "Route and Pole Numbering," TE & CM-628, "Plastic Insulated Cable Plant Layout," TE & CM-630, "Design of Aerial Cable Plant," TE & CM-635, "Construction of Aerial Cable Plant," TE & CM-636, "Aerial Cable Plant Assembly Units," TE & CM-650, "Guys and Anchors on Wire and Cable Line," TE & CM-815, "Electrical Protection of Aerial Cable," provides detail

detail information on outside plant design.

4.077 Rural Distribution Wire

4.0771 Rural distribution wire (RDW) of the jacketed type is an acceptable facility that is lower in initial cost than cable and is satisfactory for limited usage other than for main leads. It does not have a metallic shield. It may be suitable for short leads, laterals, branches, or for temporary service. Distribution wire has been used as an insert in open wire lines where heavy foliage was encountered or to facilitate joint use where spacing was critical.

4.0772 The absence of a shield causes distribution wire to be more sensitive than cable to power line noise influences and other external interference sources. There may also be variation in mutual capacitance of the pairs and higher pair-to-pair capacitance unbalance which tend to increase crosstalk. It should, therefore, not be used where the future use of carrier equipment or voice frequency repeaters is even a possibility.

4.0773 TE & CM-620 "Design and Construction of Figure 8 Distribution Wire," discusses details of this construction. See also TE & CM-611 "Design of Pole Lines," and TE & CM-650, "Guys and Anchors on Wire and Cable Lines."

4.078 Open Wire Facilities

4.0781 Although REA borrowers still have a million miles of open wire the application of open wire has diminished greatly. For several years retirements have been exceeding new wire miles that have been constructed. For new loops the use of open wire becomes a questionable choice. Cable type facilities supplemented by gain devices, proper loading, or carrier, can operate satisfactorily and economically to almost any distance.

4.0782 Comparative cost studies indicate that it is not economical to reinforce open wire facilities with additional open wire. Open wire carrier is still a useful technique for reinforcement in some parts of the United States. Cable or rural distribution wire can frequently be added to existing poles, or a buried facility can be placed along the route.

4.0783 TE & CM Sections 603, 605, 610, 611, 615, 616, 619, 625, 626, 627, 650 and 820 discuss details of open wire facilities.

4.08 Joint Use of Poles and Structural Coordination

4.081 Joint use of poles of other utilities may offer opportunity for savings in aerial outside plant costs. While maximum benefit can be expected from pole lines constructed especially for joint use, there may be significant savings possible through the use of subscriber carrier on electric pole lines. Subscribers more than 100 miles from the central office are being serviced with this technique. Important considerations are rental rates, adequacy of pole strength, sufficient pole heights for required ground clearance, and power and communications conductor separations to meet National Electrical Safety Code requirements, or local code requirements if they are more stringent. (See TE & CM-601, "Discussion of National Electrical Safety Code.")

4.082 It is the engineer's responsibility to evaluate and judge the desirability of joint use as compared with other methods of construction. Potential noise and interference problems should not be overlooked. When joint use appears favorable, firm arrangements concerning pole and attachment rental costs and costs associated with electrical protection, plus any modifications or additions required should be determined. Safety considerations must be fully evaluated.

4.083 Where aerial plant is proposed but general joint use is not planned, the engineer should make arrangements for avoidance of conflicts through the use of joint pole crossings. Joint crossings are essential for clearance and power contact protection. A coordinated protection scheme should also be arranged. The use of the multi-grounded neutral of the power system (if available) for grounding telephone circuit protective devices and the use of the preferred grounds at subscribers' premises for station protection should be incorporated into this design. (See REA TE & CM-805 "Subscriber Station Protection.")

4.084 Extensive joint use has not been proposed by REA borrowers for many years. Where extensive joint use is planned, long term joint use agreements are desired to assure the REA borrower of continuing occupancy rights and stability of rentals. This is in the interest of security of long term REA loans. The engineer assisting the owner in joint use negotiations and in making economic analysis of joint use, should be familiar with REA Bulletin 305-1 covering REA recommendations on joint use and the standard contract forms recommended therein.

4.09 Interoffice Trunking

4.091 A trunk study will be required to indicate the number and types of inter-office trunks between the various central offices.

4.092 These trunks are usually derived from voice frequency cable pairs or cable(or open wire)carrier systems. Carrier multiplex derived

circuits are also provided on microwave radio which plays an important part in deriving many high quality trunk systems. (See paragraph 4.14). In rural systems, trunk circuits are usually in the same cable as subscriber loop circuits. As the use of data circuits increase and impulse noise becomes more of a problem separate cables will become more common. The engineer must select the method of deriving the trunk circuits according to the economics involved. In the economic analysis, the time period in which various trunk requirements are anticipated will be an important factor to consider and may influence the type of trunk facility chosen. The engineer should indicate on the trunking diagram of the proposed system the estimated 5-year trunking requirements for each trunk group. It should be kept in mind in long range planning that existing open wire trunk groups and carrier on open wire facilities to be retained for the immediate future will likely be replaced due to unreliability, maintenance and other considerations and provisions should be made in the trunking plan for their future retirement.

4.093 Since the trunk circuits which the engineer is planning will often terminate in a central office owned by another company, it is imperative that the engineer work closely with the connecting company so that the type, number, and method of operation of the trunks are mutually acceptable to both the owner and the other company. The coordination of this phase of the system design work should be conducted jointly with the owner since the plan which is finally agreed upon by the two companies will involve contractual obligations on the part of the owner. (See REA Bulletin 340-3.) To best serve the interests of the owner in executing this work, the engineer must be familiar with the terms and conditions of connecting company agreements and the methods used to determine toll revenue.

4.094 The analysis of the most economical method of providing the trunk circuits will probably have to coincide with the development of the exchange outside plant requirements since primary routes and capacities will not be known until these are established.

4.095 REA TE & CM-319, "Interoffice Trunking and Signaling," -415, "Transmission Objectives," -431, "Voice-Frequency Loading for Trunk Cables," -444, "Calculation of the Net Loss of Negative Impedance Repeatered, Loaded Trunks," -904, "Application Guide for Trunk Carrier Specifications, REA Form 397b," and -930 "Use of Point-to-Point Radio (Microwave) in Telephony," contain detailed information related to the design of trunk plant.

4.10 Transmission Criteria

4.101 The primary transmission objective is to provide reliable, uniform quality, low loss circuits between subscribers within an

exchange area and between subscribers served from different central offices. Certain recommended standards or limits are established for design guidance. See TE & CM-415, "Transmission Objectives." Deviations, if any, from standard transmission criteria must be given prior REA approval. The most economical method that meets the standard objectives should be selected wherever possible.

4.102 The 400 series of the REA TE & CM provides detailed trunk and subscriber voice frequency transmission guidance.

4.11 Carrier Equipment

4.111 The 1960's saw the development of better and more reliable carrier equipment through the use of solid state components. As a result, there is now available a wide variety of transistorized carrier equipment for application over cable facilities. Telephone systems find carrier economical and useful in conjunction with new physical plant and also a practical means for planning the reinforcement of existing facilities. Carrier has inherent advantages from a transmission and signaling standpoint and frequently makes it practical to provide service to subscribers upon request. It should be chosen whenever the annual cost of carrier versus that of comparable physical plant are nearly the same because of its flexibility and versatility. It is especially advantageous if channel growth extends uniformly over the full five years. Channels can be added as required. Expansion costs can be deferred in this manner. TE & CM-901, "Fundamentals of Carrier Telephone, -905, "Cable Carrier Systems and Carrier Frequency Transmission Through Cable", -822, "Electrical Protection of Carrier Equipment," contain additional information.

4.112 Some newer types of carrier which are pulse code modulated (PCM) are lower in cost than analog type systems. The latest generation of subscriber carrier (station carrier) is available at a fraction of the cost of older types of equipment. The downward cost trend is expected to continue in the 1970's. Most of the carrier equipment available today requires a minimum of alignment during its installation and for maintenance. Station carrier equipment has been developed for subscriber use which requires no alignment at all. This equipment has been designed for ease of maintenance by the telephone companies. Experience shows that telephone maintenance personnel not trained in electronics can maintain this equipment satisfactorily.

4.113 Trunk Cable Carrier

4.1131 Several types of trunk cable carrier are available today which are of the analog (frequency division) type which has been in common use in the telephone industry for many years. With the advances

made in solid state circuitry this equipment has been improved and is very reliable. There have been few new developments in the analog trunk field in the past five years, therefore, its use should be avoided if practicable. Short range carrier systems of this type can be used for distances up to 30 miles. Other types have a longer range up to 200 miles.

4.1132 PCM equipment uses integrated circuits and its cost trends continue downward. The range of PCM carrier is considered to be 100 miles; each system can provide 24 channels on 2 cable pairs. It encompasses many new innovations such as self-checking circuits at the terminals, interrogation of line repeaters from the terminals and line repeaters which require no equalization during installation. These features make PCM attractive for rural use.

4.1133 The use of PCM carrier in a rural system should also be considered because the repeatered lines established for its transmission can be used for handling wideband data. Data channels are available which can provide 50, 250, 500 kilobit per second data channels over a T1 line. It is possible to provide combinations of voice and wideband data facilities in rural areas over two cable pairs to meet the transmission requirements of computers, facsimile, and other wideband usage.

4.1134 From a transmission standpoint, carrier is a preferred facility for long toll connecting trunks. About 27 miles is the maximum permissible distance for voice frequency trunks recommended by the 1968 Notes on Distance Dialing issued by AT & T. The reason is that the Via Net Loss Factors assigned to physical circuits impose this distance limitation. Modern carrier is generally economical at much shorter distances.

4.1135 In the United States trunks on coaxial cables have generally been restricted to long haul toll usage. However, coaxial cable carrier systems have been in widespread use for short haul trunks in Europe. Interest is now developing in Canada and the United States because its enormous circuit capability will be desirable even in rural exchanges, if picture-telephone is to be provided. It is recommended that this technique be given detailed analysis when there are requirements for more than 100 trunks.

4.1136 It has been fairly common in the past, to design trunk circuit facilities using carrier systems for part of the route with the trunks extended for another part of the route with voice frequency extensions of the carrier channels. This was necessary for economic reasons. Since the cost of carrier equipment has been greatly reduced and trunk groups are becoming larger, it is recommended that trunk circuits should be of one type - either voice frequency or a carrier derived circuit for the entire route. Furthermore, two or more carrier systems should not be connected in tandem to form a non-switched toll circuit.

4.114 Subscriber Cable Carrier

4.1141 New types of subscriber carrier (station carrier) systems developed in the 1960's can serve as many as 6 one-party or 24 four-party subscribers located nearly 50 miles from the central office over one 19 gauge cable pair. Station carrier is designed exclusively for cable facilities. It is not intended to be used on open wire plant. Repeaters and subscriber terminals for this equipment are powered over a cable pair from the central office. Regulation is such that the channel voice frequency loss is independent of length of circuit and the repeaters and channel equipment do not require adjustments during installation or for maintenance. The installation is simple. The subscriber's terminal is located on a pole, in a housing above ground, buried in the ground or installed in the home.

4.1142 Extensive use has been made of station carrier to provide additional circuits on cable facilities which cannot be readily expanded and thus immediately provide for additional demands for service. Since this equipment is easily installed, it can also be easily removed. Where it is likely to be an asset, for example, when the rural population is decreasing or where extensive future growth is expected but the rate at which houses are to be built is uncertain engineers design telephone systems employing the concept of a minimum of fixed plant and a maximum of movable plant. The advantage is that the station carrier may be bought in small quantities over a long period of time when needed and the initial investment normally required for extra pairs in cable facilities is avoided.

4.1143 Subscriber carrier can be used to provide circuits in one location at points distant from the central office from which a distribution of subscriber circuits is to be made. This avoids the need for small central offices throughout the area, and all central office equipment is concentrated in a larger office. Almost all types of available subscriber carrier can be used for this application-station carrier, as well as the older types of subscriber carrier systems which have been available for 10 years or more.

4.1144 Several types of single channel station carrier systems are available which can be used on nonloaded cable circuits and retain the use of the voice frequency circuit. This equipment costs about one-half the cost of multi channel station carrier and has found widespread use throughout the telephone industry.

4.1145 A 1971 version of station carrier provides a basic unit of up to 24 channels over a T1 type PCM carrier line (2 cable pairs). This unit is easily expansible to 96 subscribers by combining it with an electronic switching arrangement. In addition to its obvious use in

new housing developments, trailer parks, shopping centers, apartments, etc. It is expected to replace or be a substitute for small dial offices whose subscribers could get the most modern telephone services from a large remotely located common control switchboard. It has the same range as T carrier, approximately 100 miles.

4.1146 TE & CM Sections 911 and 912 describe station carrier equipment.

4.115 Open Wire Carrier

4.1151 Transistorized open wire carrier of several types and features is available for both trunk and subscriber plant. It should not be used where icing, frost buildup, or tree clearing are problems. Generally it should only be used when all other economic alternatives have been exhausted.

4.1152 Open wire trunk carrier is still used in certain parts of the United States. Although solid state open wire carrier is preferred, it may be necessary to use tube type equipment for compatibility since some of the equipment has not been updated. It is anticipated that open wire plant will have decreasing use in the 1970's, but in rural areas which are sparsely settled and include many miles of trunk route from the unattended central office to the toll center, there still may be a need for open wire carrier equipment.

4.1153 Open wire subscriber carrier is also still being used to a limited extent in sparsely settled areas of the country. It is designed for both multiparty use or for individual subscriber service. It should not be used unless other methods are clearly uneconomical. The physical facility is often joint use with an electric distribution line. There are exchanges in operation with open wire subscriber carrier that have 100-mile long subscriber loops. Using this equipment, rural telephony has been extended into areas where, at the time, it was not possible to provide telephone service by any other means - from an economic as well as a transmission standpoint. Up to 12 channels plus retention of the physical circuit is possible with this carrier. REA TE & CM-290, "Expansion of Existing Facilities With Trunk and Subscriber Carrier Systems" and -910, Subscriber Carrier Equipment" describes open wire carrier application.

4.1154 Where open wire carrier systems are used as a means of supplementing physical plant, special attention should be given to proper transposition systems, type of conductor, joint use exposure, etc., to insure maximum performance. The REA-1 transposition system, for example, makes it possible for a large number of carrier channels to be utilized along a given route either in initial or future application. Less desirable transposition system designs can severely limit the number of carrier channels permissible along a route.

4.12 Voice Frequency Repeaters

4.121 Voice frequency repeaters should be used on medium length (10-20 mile) toll and EAS physical trunks to offset transmission losses.

4.122 In many instances the application of voice frequency repeaters or suitable loaded cable facilities may permit considerable savings in the cost of the physical circuits by allowing the cable conductors to be of a smaller gauge. Repeaters of this type will prove to be a practical way to attain recommended transmission levels on existing trunks.

4.123 Negative resistance voice frequency repeaters are reasonable in initial cost, are small in size, with D-66 loading they can be used at either or both end offices of a trunk circuit and/or at an intermediate location. They are transistorized and equipped to operate from 48-volt central office battery with low current drain. They have built-in impedance matching features for easy adjustments.

4.124 Negative resistance voice frequency repeaters are used for subscriber loop applications to extend loaded 19 gauge cable loops to almost 50 miles and also to utilize finer gauge cable conductors at shorter distnaces. Pole or pedestal mounting for field units have proven practical during the past five years.

4.13 Common Mode Operation (CMO)

4.131 A technique for sharing voice frequency repeaters and long line adapters within the central office equipment switching systems similar to the Bell System's Unigauge switching system developed for #5 crossbar and electronic switchboards has significantly reduced the cost of providing service in step-by-step offices. REA's "common mode" operation allows a group of long lines to share use of a reduced number of long line adapters and voice frequency repeaters, as the intra-office trunks are shared.

4.132 The arrangement dedicates one or more linefinder groups and connector groups to the exclusive use of long subscriber loops. Adapters and repeaters are placed between the linefinders and first selectors of the dedicated linefinder group. Elevated d.c. voltages are used to increase the loop range. Repeaters are also used in conjunction with the dedicated central office connectors. In this manner, the number of long line adapters and voice frequency repeaters required is reduced to less than one third of the individual line requirements.

4.133 CMO is most useful and economical where there are 20 or more long subscriber lines to make a step-by-step group for sharing the long

line equipment. The arrangement can be used with new central offices or with existing equipment. In common control offices the breakeven point is greater than 20 lines but less than 100.

4.134 TE & CM 429, "Design of Subscriber Loop Plant Common Mode Operation," and TE & CM 331, "The Application of Common Mode Operatior to Central Office Equipment," discuss details of the method.

4.14 Microwave

4.141 Point-to-point radio (microwave) is used to provide trunks between central offices (1) in areas of mountainous terrain, (2) over watery or wooded areas which would cause excessive conventional costs (3) where physical trunks would be inaccessible for maintenance, (4) where an unusually large number of trunks are needed, (5) areas which experience severe wind and ice conditions and buried plant is not practical, and (6) in other situations where it can be shown to be advantageous.

4.142 Microwave equipment can provide a transmission path for an almost unlimited number (600 or more per RF frequency) of voice frequency trunks. Special services including wide band data, picture telephone and television can also be transmitted over microwave systems. FCC authorizations must be obtained for construction and operation of all radio facili ties.

4.143 Trends in microwave terminals are towards (1) solid states devices, (2) increasing RF power output of solid state transmitters, and (3) carrying larger number of voice channels. The combined effect has caused approximately a 40 to 1 reduction in equipment size, per voice chan- nel, in the last 15 years.

4.144 Solid state equipment has (1) made economical, batteries sized for 24 hours of reserve, (2) reduced the needs for motor generators and (3) made cabinet housing practical, where buildings were previously required.

4.145 In the 60's, passive (billboard) repeaters began replacing active repeaters which have a minimum of two transmitters and two receivers. Where required, a new lower cost active repeater is available in the 2GHz band whose operation is similar to a carrier frequency frogging repeater.

4.146 REA TE & CM 930, "Use of Point-to-Point Radio in Telephony," discusses various features and applications of microwave radio equipment. REA TE & CM 931, "Microwave Propagation and Path Surveys," discusses technical information used to design a suitable radio path between microwave stations. REA TE & CM 932, "Microwave System Preparation Guide for

FCC and FAA Requirements," discusses contents of FCC and FAA forms. It also includes information about frequency selection and radio interference considerations. REA TE & CM 933 "Application Guide for Point-to-Point Microwave Radio System Specifications, REA Form 397d," discusses in detail the many considerations essential to planning a trunking facility using carrier multiplex derived circuits over micro-wave radio.

4.15 Mobile Radio

4.151 Radiotelephone equipment is available for manual and dial service to mobile subscribers and subscribers at fixed locations. The manual type requires an operator to make the connection between the radio-telephone system and the wire line system. The operator must dial the called party after receiving oral instructions from the calling party. The dial type operates through unattended dial central offices. Mobile radio is also useful in the operation and maintenance of telephone system facilities. This service may be provided telephone system vehicles on a secondary basis along with mobile subscribers, or it may be provided using a separate system strictly as an operations and maintenance tool.

4.152 TE & CM 945 "IMTS - Improved Mobile Telephone System," describes the operation and application of dial radio telephone equipment. Mobile radio in telephone system vehicles is an excellent tool in the operation and maintenance of telephone system facilities. Refer also to TOM 1092 "Getting the Most Out of Your Two Way Radio," for more information.

4.153 Subscriber radio link equipment is available for serving subscribers at fixed residences. It consists of a central office terminal and a subscriber terminal to form a radio "loop" dedicated to serving one to four subscribers.

4.154 FCC authorization must be obtained to construct and operate a radio facility. REA Bulletin 385-1, "Preloan Procedures and Requirements for Two-Way Radio Telephone Equipment for Operation and Maintenance of Telephone Systems and Subscriber Service," contain additional information. (See also TE & CM 940, "Use of Mobile and Fixed Radio Telephone for Subscriber Service and for Operation and Maintenance.")

4.16 Analysis of Types of Station Equipment

4.161 A study of the demand for various types of subscriber equipment must be made by the engineer showing the number of wall, desk, decorator, and key stations, paystations, data sets, pushbutton sets, etc., in order to properly prepare the cost estimate needed for the ACD.

.162 Since the Carterfone decision in 1968, telephone companies can no longer prohibit the connection of subscriber owned equipment to mmon carrier telephone lines. Because of this, the probable quantity d types of subscriber owned equipment should be estimated during the area verage survey. To an extent, the telephone systems' tariff will affect e percentage of stations, key systems, data sets, etc., that are subriber owned. Outside plant and central office facilities will generally required for the full number of such installations.

.163 Within some systems, there will be a desire for centrex, computer access, facsimile, private branch exchanges and private automatic anch exchange, two line telephones, farm or home intercom systems, key ephone systems, automatic answering devices, hands free instruments, other special equipment and services. The engineer must include such ilities as required by the ACS.

17 Design and Construction of Buildings

171 There are several types of buildings suitable for housing unattended dial switching equipment. The engineer should make cer- that the size of the proposed structure is sufficient for equipment uired to serve the system for 10 or more years in the future. Among s to consider, in addition to switching equipment, are future elec- ic equipment requirements, connecting facilities, future common con-, or equipment pertaining to new subscriber services.

72 The choice of a proper building in a particular situation involves: (a) type of construction which will result in appearances improving n keeping with other buildings in the particular location, (b) compari- of annual costs, including insurance costs on the building and equip- for the various types of structures adequate for the area: Example: sonry building may have higher costs of construction than a van type l building, furnished with a dial central office but the difference en fire insurance rates for the two types when applied to the build- and their contents in the particular area may make the annual costs e masonry building and contents much lower.

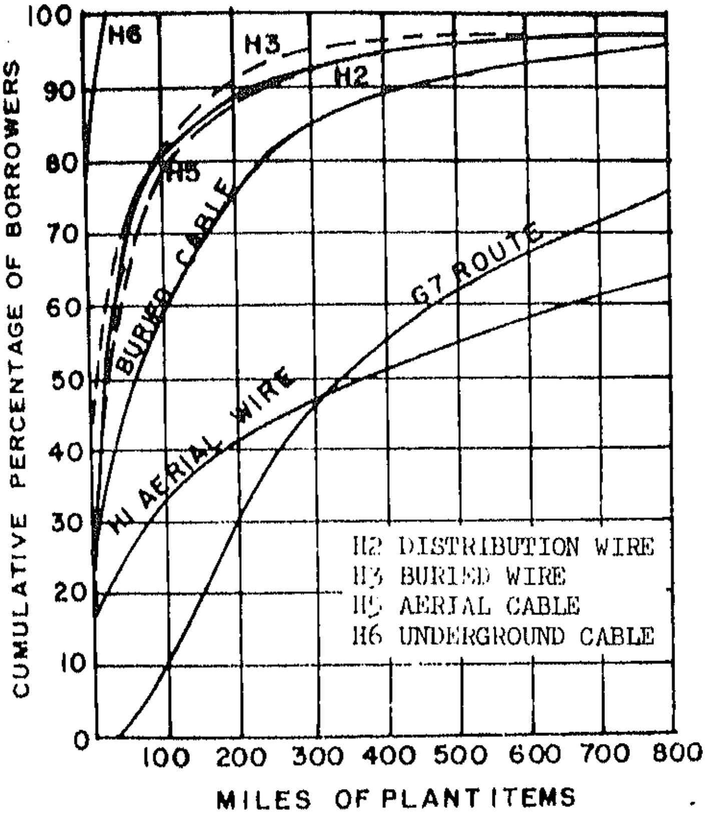
3 REA standard masonry building specifications include most essential features , including heating and interior insulation. Air condition- s frequently specified. Electric and chemical toilets are available can be installed without water and sewage disposal systems.

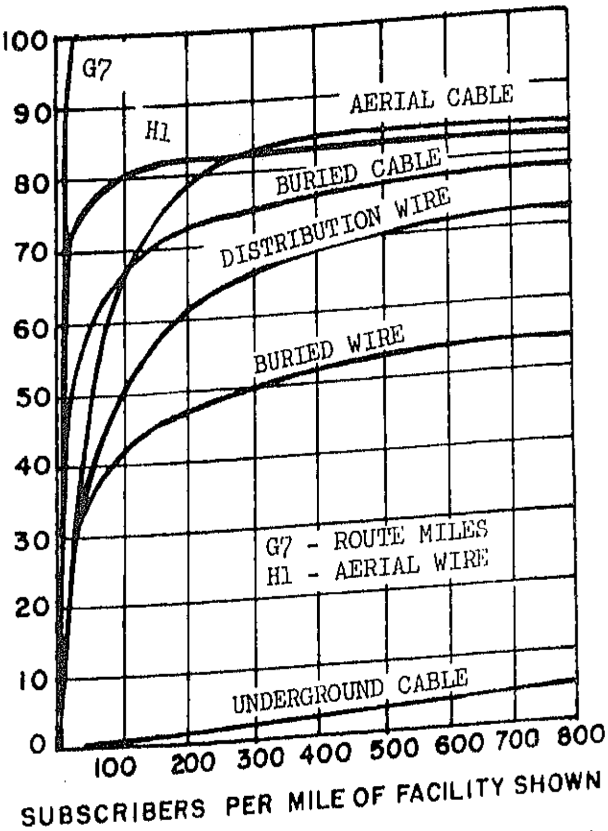
4 The conditions under which headquarters buildings will be considered in a loan are outlined in REA Bulletin 320-5.

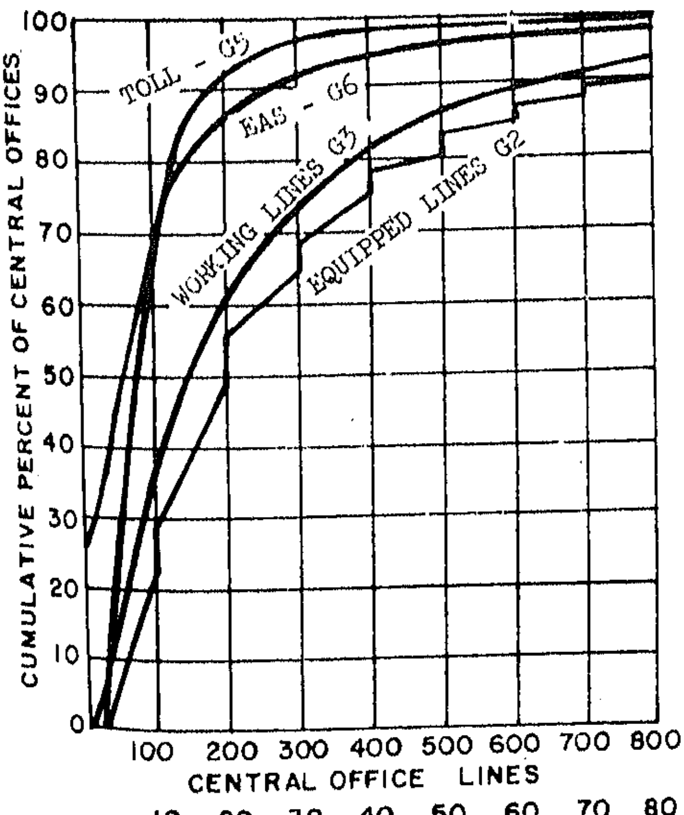
5 For extensive remodeling of existing buildings, it is necessary that a qualified architect examine the structure and submit a s concerning the extent and estimated cost of the remodeling.

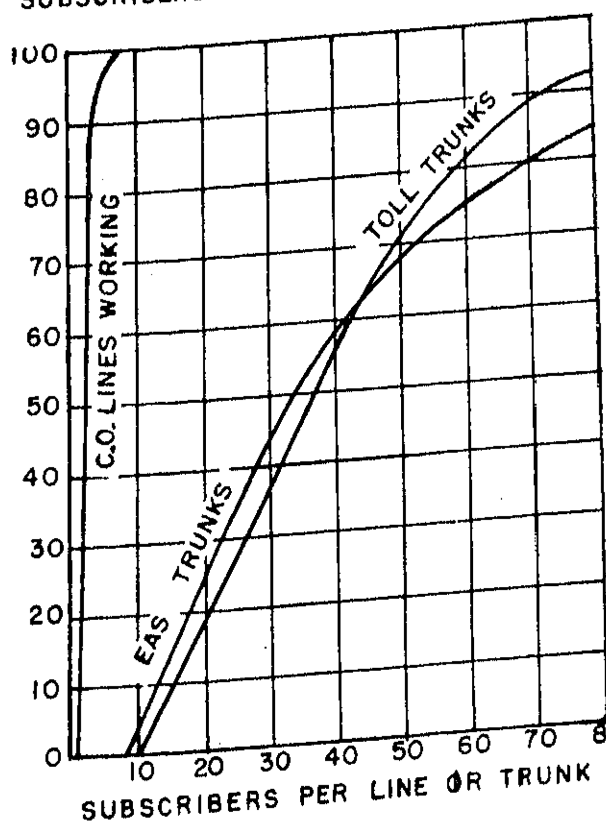
REA TE & CM 204

Statistical Data for 797 REA Borrowers
Showing the Base Upon Which New Services and
Facilities Will be Superimposed in the Seventies









INVESTMENT IN TELEPHONE PLANT IN SERVICE

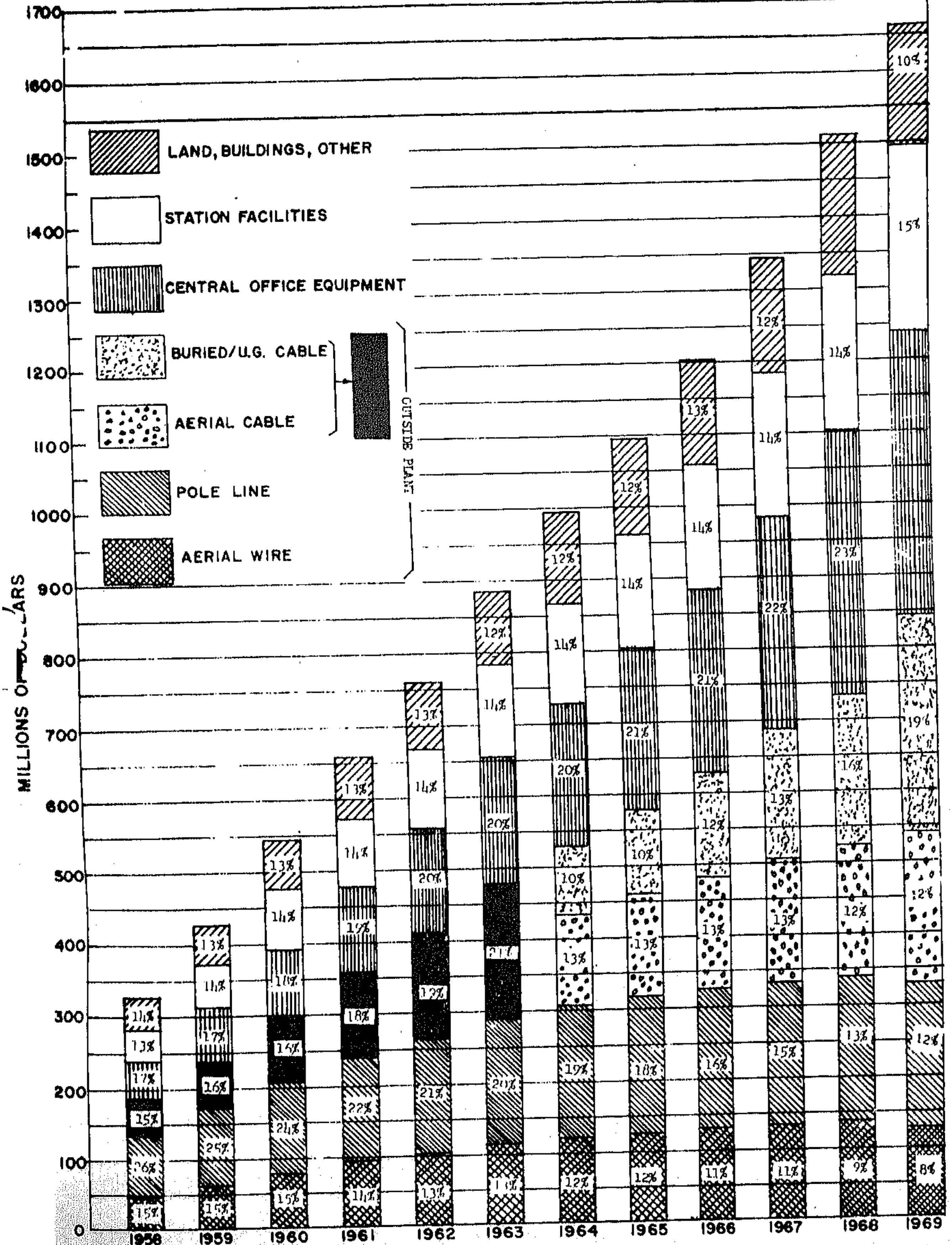


FIGURE 2